A few words about dark matter and dark energy.

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In simple words, dark matter and dark energy is the work of the forces of gravity in galaxies and the observable Universe.

The fact is that the concepts of ‘dark matter’ and ‘dark energy’ were introduced into physics to explain the motion of stars in galaxies and the removal of galaxies in the observed Universe. The term ‘dark’ means that matter and energy do not participate in electromagnetic interaction and therefore are inaccessible to direct observation.

1. Anomalies in the observed orbital velocities of stars in galaxies are explained by invisible, that is, dark matter.

2. The reason for the acceleration and removal of galaxies in the observed Universe is explained by the work of invisible, that is, dark energy.

But, using only Newton's law of gravity, it is possible to correctly explain both the motion of stars in galaxies and the accelerated recession of galaxies in the observable Universe. Here is a short proof.

So, Newton's law says that two point masses (M, m) located at a distance r attract each other with a force F.

$$F = G * (M * m) / r^2$$

G - is the gravitational constant.

Therefore, all bodies move under the action of gravity with a certain acceleration (a) in accordance with Newton's second law (F = m * a, m - is the mass of the test body).

$$a = G * M / r^2$$

According to this formula, the Earth moves around the Sun and the apple falls to the Earth. I would like to emphasize that the masses that attract each other can be strictly considered pointlike. In general, all bodies in the Universe move according to the above formula.

If we have a certain volume of space with many different masses, then our test body (m) will move along a trajectory with a certain acceleration and speed. Moreover, the acceleration (and speed) of the test body at each point of the trajectory will be the resulting vector of accelerations (and speeds) of all bodies in a given volume of space. In Einstein's general relativity, this is interpreted as a curvature of space-time.

In order to explain the motion of stars in galaxies and the accelerated recession of galaxies in the Universe, it is necessary to simply take into account the dependence of mass on distance in the above formula ($a = G * M / r^2$). This turns out to be enough.

Galaxies are flat discs. Moreover, the mass of the galaxy is almost evenly distributed over the disk (and this is despite the presence of giant black holes in the center of the galaxy!). Compare this to the Solar system in which the mass is concentrated mainly in the center of the system (the Sun).

Let us assume that the galaxy is a two-dimensional disk of radius r with matter density ρ. Then the mass of the galaxy will be:

$$M = \pi * r^2 * \rho$$

Taking into account the acceleration formula ($a = G * M / r^2$), it is easy to obtain the dependence of the speed of stars in galaxies on the radius of the trajectory.

$$a = G * M / r^2 = G / r^2 * \pi * r^2 * \rho$$

$$a = G * \pi * \rho$$

The acceleration of stars is constant and depends on the characteristics of the galaxy. This means that the stars in galaxies are in free fall: the stars literally fall on the galaxy, like artificial satellites fall on the Earth. The acceleration of stars is the acceleration of free fall of a given star for a given galaxy.

Then the speed of stars in galaxies that move in a circle of radius r will be equal to.

$$v = (G * \pi * \rho)^{0.5} * r^{0.5}$$

$$v = X * r^{0.5}$$

where $X = (G * \pi * \rho)^{0.5}$

The resulting formula is fully consistent with the experimental data.

To explain the accelerated removal of galaxies in the Universe, it is necessary to take into account in the formula ($a = G * M / r^2$) that the mass in the observed Universe is evenly distributed in space. Then the mass of a ball of radius r will be equal to:

$$M = 4/3 * \pi * r^3 * \rho$$

where ρ - is the density of matter in the observable Universe.

From this it is easy to obtain the dependence of the orbital velocity of galaxies on the radius of the sphere.

$$a = G * M / r^2 = G / r^2 * 4/3 * \pi * r^3 * \rho$$

$$a = 4/3 * G * \pi * \rho * r$$

$$v = (4/3 * G * \pi * \rho) ^ 0.5 * r$$

That is, the further the galaxy is from the center of the ball, the greater its orbital acceleration and speed will be. Naturally, the speed of light will determine the horizon of our visible Universe.

Taking into account the gravitational potential at the center of the ball and on its surface, it is possible to obtain the dependence of the linear acceleration and the rate of departure of galaxies from the center of the ball [1].

$$a = (2 * \pi * \rho * G * r) / 3$$

In an abbreviated form, you can write:

$$a = K * r$$

where K - is a constant, $K = (2 * \pi * \rho * G) / 3$

r - is the distance from the center of the ball to the position of the galaxy.

That is, galaxies will accelerate all the time, since their acceleration is directly proportional to the distance from the center of the ball. In fact, galaxies fall across the entire visible universe. Then the linear velocity of the galaxy receding, that is, the Hubble-Lemaitre law takes the form ($a = v^2 / (2 * r)$):

$$v = (4/3 * \pi * \rho * G)^{0.5} * r$$

$$v = H * r$$

where $H = (4/3 * \pi * \rho * G)^{0.5}$

Thus, using only Newton's law of gravity, without using the concepts of dark matter and dark energy, it is possible to correctly explain the anomalies in the motion of stars in galaxies and the accelerated recession of galaxies in the visible Universe. Not bad for Newton's law of gravity...

1. Bezverkhniy V. D., Bezverkhniy V. V. Limiting the Speed of Light, Gravitational Potential, and the Removal and Acceleration of Galaxies in the Universe. SSRN Electronic Journal (2021). P. 5. DOI: 10.2139/ssrn.3776718. https://vixra.org/pdf/2101.0184v1.pdf